PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

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NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(PCT Rule 71.1)

Date of mailing *(day/month/year)*	05.12.2005
Applicant's or agent's file reference	**IMPORTANT NOTIFICATION**
P-PWU-491WO	

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP2004/053264	03.12.2004	03.12.2003

Applicant
PAUL WURTH S.A.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary report on patentability and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary report on patentability. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

The applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purposes of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purposes of deciding whether, in that State, the claimed inventions is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

Name and mailing address of the international preliminary examining authority:

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PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P-PWU-491WO	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/EP2004/053264	International filing date *(day/month/year)* 03.12.2004	Priority date *(day/month/year)* 03.12.2003
International Patent Classification (IPC) or national classification and IPC C21B7/10		
Applicant PAUL WURTH S.A.		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 5 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 7 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

Date of submission of the demand 02.07.2005	Date of completion of this report 05.12.2005
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized Officer Ceulemans, J Telephone No. +31 70 340-3157

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/EP2004/053264

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:

   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages

1, 2, 5-7, 9-18	as originally filed
3, 4, 8	received on 07.10.2005 with letter of 03.10.2005

Claims, Numbers

1-34	received on 07.10.2005 with letter of 03.10.2005

Drawings, Figures

1-15	as originally filed

☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/EP2004/053264

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-34
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-34
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-34
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

D1: DATABASE WPI Section Ch, Week 197619 Derwent Publications Ltd., London, GB; Class J08, AN 1976-35010X XP002282752 -& JP 51 035661 A (NIPPON ALUMIN MFG) 26 March 1976 (1976-03-26)

D2: GB-A-2 079 655 (CONNELL JOHN O; REDPATH ENGINEERING LTD) 27 January 1982 (1982-01-27)

D3: DE 33 13 998 A (VOEST ALPINE AG) 8 December 1983 (1983-12-08)

D4: EP-A-1 156 124 (KM EUROPA METAL AKTIENGESELLSCHAFT) 21 November 2001 (2001-11-21)

D5: DATABASE COMPENDEX [Online] ENGINEERING INFORMATION, INC., NEW YORK, NY, US; ABDULALIYEV Z E ET AL: "Analysis of stresses in tube sheet of heat exchanger by three dimensional models" XP002282751 Database accession no. EIX99254647555

The document D3 is regarded as being the closest prior art to the subject-matter of claims 1 and 24, and shows (the references in parentheses applying to this document):
a cooling plate for a metallurgical furnace, providing a metallic plate body with at least one channel extending through and within said plate body. A metallic tube is inserted into said channel, with its ends protruding from said channel. The tube will have a press-fit connection to the plate body in use, due to thermal expansion of the tube beyond the diameter of the channel in use.

The subject-matter of claim 1 differs from this known process in that a metal-forming process is applied to the plate body in order to achieve the press-fit connection between the tube and the body.
The subject-matter of claim 24 differs from this known cooling plate in that a plastic deformation is present in the plate body along the channel providing a press-fit connection between the tube and the body.

The subject-matter of claims 1 and 24 is therefore new (Article 33(2) PCT).

The problem to be solved by the present invention may be regarded as providing a more cost-effective way of obtaining a press-fit connection between the cooling pipe and the plate body.

The solution to this problem proposed in claims 1 and 24 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons.
In order to obtain the press-fit connection, a metal-forming process is applied to the metal plate body. The cooling plate is locally plastically deformed, thereby ensuring the press-fit.
D1 and D2 disclose a process for obtaining a press-fit connection between a tube and a sheet by pressing a tube into a groove or slit in the surface of the sheet and thereby deforming the tube to achieve the press-fit connection.
Although the disclosures of D1 and D2 concern heat exchanging devices, they do not consider cooling plates for a metallurgical furnace, i.e. plate bodies with cooling channels running through and embedded within ; on the contrary, both consider relatively thin sheets with no structural function and which are not thick enough for cooling pipes to run through them.
Hence the person skilled in the art would not have been led by the disclosure of either of D1 or D2 to apply a metal-forming operation to the metal body of a cooling plate for a metallurgical furnace, incorporating cooling tubes within said body, to obtain a press-fit connection between said body and said tubes by means of a local plastic deformation of the plate body.

Claims 2-23 and 35-34 are dependent on claim 1, 24 respectively, and as such also meets the requirements of the PCT with respect to novelty and inventive step.

CLAIMS

1. A method of manufacturing a cooling plate for a metallurgical furnace comprising:

providing a metallic plate body (10, 10', 10'') with a front face (12, 12'), a rear face (14, 14') and at least one channel (22, 22') extending through said metallic plate body (10, 10', 10'') beneath said front face (12, 12');

inserting, with radial clearance, a metallic tube (30, 30') into said channel (22, 22') so that both tube (30, 30') ends protrude out of said channel (22, 22'); and

achieving a press fit of said tube (30, 30') within said channel (22, 22');

characterized in that the step of achieving a press fit of said tube (30, 30') within said channel (22, 22') comprises a metal-forming process applied to said metallic plate body (10, 10', 10'').

2. The method as claimed in claim 1, wherein said metal-forming process provides an elastic deformation of said tube (30, 30') so as to produce a pre-tensioned fit of said tube (30, 30') in said channel (22, 22').

3. The method as claimed in claim 1 or 2, wherein the step of providing a metallic plate body (10, 10', 10'') with at least one channel (22, 22') comprises:

a) providing a forged or rolled copper or steel slab; and

b) drilling said at least one channel (22, 22') through said slab.

4. The method as claimed in claim 1 or 2, wherein the step of providing a metallic plate body (10, 10', 10'') with at least one channel (22, 22') comprises:

continuously casting a metallic slab with at least one cast-in channel (22, 22') extending there through; and

manufacturing said metallic plate body (10, 10', 10'') out of said continuously cast metallic slab.

5. The method as claimed in claim 4, wherein the step of manufacturing said metallic plate body (10, 10', 10") comprises:

machining said at least one cast-in channel (22, 22') with a metal-cutting tool so as to improve its dimensional and form tolerances.

6. The method as claimed in any one of claims 1 to 5, wherein the step of achieving a press fit of said tube (30, 30') within said channel (22, 22') comprises a metal-forming process applied locally along said at least one channel (22, 22').

7. The method as claimed in claim 6, wherein a depression (90) is formed along said channel (22, 22') by means of said metal forming process.

8. The method as claimed in any one of claims 1 to 7, wherein the step of providing a metallic plate body (10, 10', 10") with at least one channel (22, 22') comprises:

providing a bulge (80) on said metallic plate body (10, 10', 10"), said bulge extending along said at least one channel (22, 22').

9. The method as claimed in claim 8, wherein the step of providing a metallic plate body (10, 10', 10") with at least one channel (22, 22') further comprises:

providing an aperture (82) within said bulge (80).

10. The method as claimed in claim 8, wherein the step of providing a metallic plate body (10, 10', 10") with at least one channel (22, 22') further comprises:

providing an aperture (82) within said bulge (80), wherein said aperture (82) extends into said at least one channel (22, 22').

11. The method as claimed in claim 10, wherein said metal-forming process is applied to said bulge (80) so as to reduce the width of said aperture (82).

12. The method as claimed in any one of claims 8 to 11, wherein said metal-forming process is applied to said bulge (80) so as to depress the latter.

13. The method as claimed in any one of claims 1 to 12, wherein the step of

achieving a press fit of said tube (30, 30') within said channel (22, 22') comprises:

rolling down said plate body (10, 10', 10") after insertion of said metallic tube (30, 30') in said channel (22, 22').

14. The method as claimed in claim 13, wherein said plate body (10, 10', 10") is rolled down so as to confer an oval section to said channel (22, 22') and said tube (30, 30').

15. The method as claimed in any one of claims 1 to 14, wherein the step of achieving a press fit of said tube (30, 30') within said channel (22, 22') further comprises:

radially expanding said tube (30, 30') by establishing a hydraulic pressure inside said tube (30, 30').

16. The method as claimed in any one of claims 1 to 15, wherein the step of achieving a press fit of said tube (30, 30') within said channel (22, 22') further comprises:

radially expanding said tube (30, 30') with at least one explosion inside.

17. The method as claimed in any one of claims 1 to 16, wherein the step of achieving a press fit of said tube (30, 30') within said channel (22, 22') further comprises:

expanding said tube (30, 30') by pulling an expansion head there through.

18. The method as claimed in any one of claims 1 to 17, wherein said plate body (10, 10', 10") is made of copper or steel.

19. The method as claimed in claim 1 to 18, wherein said tube (30, 30') is made of copper or stainless steel.

20. The method as claimed in any one of claims 1 to 19, wherein:

each of said tube (30, 30') ends protruding out of said channel (22, 22') is bent towards the rear of the plate body (10, 10', 10"), so as to form a connection pipe-end pointing in a direction substantially perpendicular to a plane parallel to the rear face (14, 14') of the plate body (10, 10', 10").

21. The method as claimed in any one of claims 1 to 20, wherein the step of providing a metallic plate body (10, 10', 10") comprises:

providing a plate body (10, 10', 10") with a first perimeter face (16, 16') and an opposite second perimeter face (18, 18'), wherein said at least one channel (22, 22') extends through said metallic plate body (10, 10', 10") so as to form a first opening (24, 24') in said first perimeter face (16, 16') and a second opening (26, 26') in said second perimeter face (18, 18').

22. The method as claimed in claim 21, wherein at least one of said perimeter faces (16, 18) is bevelled towards the rear face (14) of said plate body (10).

23. The method as claimed in claim 21, wherein for at least one of said openings (24', 26'), a recess (70, 72) is milled into said perimeter face (16', 18'), so that said recess is open towards the rear face (14') of the plate body (10'), and so that said opening (24', 26') lies within said recess (70, 72).

24. A cooling plate for a metallurgical furnace comprising a metallic plate body (10, 10', 10") with a front face (12, 12'), a rear face (14, 14') and at least one metallic tube (30, 30') in a channel (22, 22') extending through said metallic plate body (10, 10', 10") beneath said front face (12, 12') so that both tube (30, 30') ends protrude out of said plate body (10, 10', 10"), with a press fit between said metallic plate body (10, 10', 10") and said at least one metallic tube (30, 30'),

characterized by a plastic deformation of said metallic plate body (10, 10', 10") along said channel (22, 22'), said plastic deformation providing a predominant contribution to said press fit.

25. The cooling plate as claimed in claim 24, wherein said plate body (10, 10', 10") initially comprises a bulge (80) extending along said at least one channel (22, 22').

26. The cooling plate as claimed in claim 25, wherein an aperture (82) is provided in said bulge (80).

27. The cooling plate as claimed in claim 26, wherein, after plastic deformation of said plate body (10, 10', 10") and more specifically said bulge (80), a slit

is provided along said at least one channel (22, 22'), said slit originating from said aperture (82).

28. The cooling plate as claimed in any one of claims 24 to 27, wherein said plate body (10, 10', 10") is made of copper or steel.

29. The cooling plate as claimed in any one of claims 24 to 28, wherein said tube (30, 30') is made of copper or stainless steel.

30. The cooling plate as claimed in claim 29, wherein said plate body (10, 10', 10") is made of steel and said tube (30, 30') is made of copper.

31. The cooling plate as claimed in any one of claims 24 to 30, wherein:

each of said tube (30, 30') ends is bent so as to form a connection pipe-end (60, 62, 60', 62') pointing in a direction substantially perpendicular to a plane parallel to the rear face (14, 14') of the plate body (10, 10', 10").

32. The cooling plate as claimed in any one of claims 24 to 31, wherein:

said plate body (10, 10', 10") has a first perimeter face (16, 16') and a second perimeter face (18, 18'); and

said at least one tube (30, 30') extends through said metallic plate body (10, 10', 10") so that one tube (30, 30') end emerges out of said first perimeter face (16, 16') and the other tube (30, 30') end emerges out of said second perimeter face (18', 18').

33. The cooling plate as claimed in claim 32, wherein at least one of said perimeter faces (16, 18) is bevelled towards the rear face (14) of said plate body (10).

34. The cooling plate as claimed in claim 32, wherein at least one of said perimeter faces (16', 18') includes a recess (70, 72) that is open towards said rear face (14') of said plate body (10') and in which said tube (30') end emerges out of said plate body (10').

bores which open out into the through-passages, are drilled into the plate body perpendicular to the rear surface, and the end-side openings of the cast-in ducts are closed. Thereafter, connection pipe-ends are inserted into the connection bores and soldered or welded in place, as has already been described above.

The manufacturing methods described in DE-A 2907511 and in WO 98/30345 both enable high-quality cooling plate bodies to be produced from copper or copper alloys. However, compared to cooling plates with integrally cast cooling tubes or compared to shape-cast cooling plates, the finished cooling plates produced by both processes have the drawback of having a relatively high pressure loss in the region of the transitions from the connection pipe-ends to the cooling passages.

WO 00/36154 has suggested to reduce the flow losses in copper cooling plates with integrally cast or drilled cooling passages by inserting a shaped piece into a cutout in the cooling plate body, so as to form a diverting passage with optimized flow conditions for the cooling medium. However, this solution is relatively labor-intensive, which is reflected in higher production costs.

DE-A 3313998 discloses a cooling plate for metallurgical furnaces made of a cast iron body. The cooling plate comprises a channel for cooling fluid formed by a steel tube inserted into a bore which extends longitudinally through the body. The steel tube is fixed within the cast iron body at temperature equilibrium by means of a previous shrinkage fit. This solution requires expensive large size shrinkage fit equipment adapted to the dimensions of the cast iron body and the steel tube.

Summary of the Invention

It is an object of the present invention to provide a simple and reliable method of manufacturing cooling plates for a metallurgical furnace with relatively low pressure losses. It is another object of the present invention to provide a reliable cooling plate with relatively low pressure losses that can be easily manufactured. These problems are solved by a method in accordance with

claim 1, respectively a cooling plate in accordance with claim 24.

A method of manufacturing a cooling plate for a metallurgical furnace in accordance with the present invention comprises the following steps: providing a metallic plate body with a front face, a rear face and at least one channel extending through the metallic plate body beneath its front face; inserting, with radial clearance, a metallic tube into the channel so that both tube ends protrude out of the channel, and achieving a press fit of the tube within the channel. According to an important aspect, the press fit is obtained through a metal-forming process applied to the metallic plate body. This metal-forming process results in shrinking of the section of the channel.

Surprisingly, it has been found that a press fit of the tube in the channel can be obtained in simple, economical and reliable manner by applying a metal-forming process to the blank plate body.

After insertion of the tube, the metal-forming process transforms the metallic plate body into the desired shape for achieving the press fit of the tube within the channel. The metal-forming process includes a permanent mechanical, i.e. plastic deformation of the blank metallic plate body. Possible metal-forming processes are for example forging, pressing or rolling of the metallic plate body. The metal-forming process can convert the plate body from blank condition into the finished condition of the cooling plate. While not excluded, an additional treatment is generally not required to achieve the press fit.

Preferably, the metal-forming process is applied locally along said at least one channel. Local application reduces the required effort or force to produce the press fit and therefore facilitates the machining process and reduces the requirements on the required equipment. For example, the press fit may be achieved by producing a permanent depression along said channel, e.g. on the rear face of the metallic plate body. Alternatively, the entire metallic-plate body may be subjected to the metal-forming process.

In a preferred embodiment of the method, the metal-forming process applied to the metallic plate body provides an elastic deformation of the tube so as to produce a pre-tensioned fit of the tube in the channel. By giving a predeter-

perimeter faces of the plate body. The perimeter faces are advantageously bevelled towards the rear face of the plate body, so that they form noses protecting the tube ends emerging out of the perimeter faces. To even better protect the tube ends emerging out of the perimeter faces, it is also possible to mill a recess into the perimeter face, so that the recess is open towards the rear face of the plate body and one of the channel openings lies within this recess.

A cooling plate for a metallurgical furnace in accordance with the present invention comprises a metallic plate body with a front face, a rear face and at least one metallic tube extending through the metallic plate body beneath the front face so that both tube ends protrude out of the plate body. There is a press fit between the metallic plate body and the at least one metallic tube. According to an important aspect, the plate body is plastically deformed along said channel. It will be appreciated that plastic forming of the blank plate body provides a predominant contribution to the press fit.

In a preferred embodiment, the metallic plate body comprises a bulge extending along said at least one channel. The bulge can be provided on the front or the rear face of the plate body, in proximity of the channel along which it extends. The bulge associated to the channel significantly facilitates the metal-forming process, or plastic deformation, of the region around the channel to obtain the press fit. Accordingly, the metal-forming process can be achieved by depression of the bulge with respect to the plate body. In order to further simplify the deformation an aperture is preferably provided within said bulge. In this case, the bulge is preferably located on the rear face of the plate body.

The plate body is advantageously made of copper or steel. The tube is preferably made of copper or stainless steel. It has been found that a combination of a plate body made of steel and a tube made of copper is particularly effective. Each of the protruding tube ends is advantageously bent so as to form a connection pipe-end pointing in a direction substantially perpendicular to a plane parallel to the rear face of the plate body.